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High-T_g TOPAS mPOF strain sensing at 110 degrees

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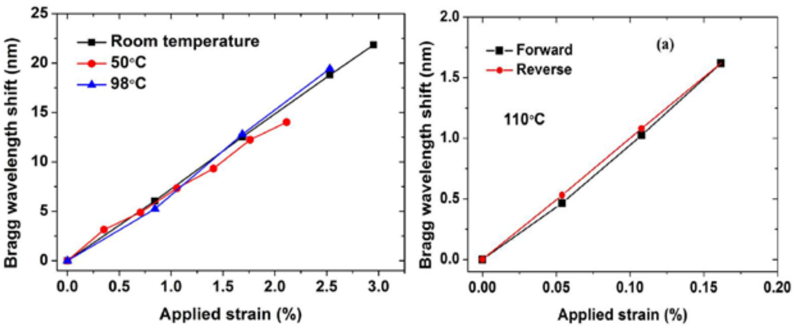
Abstract: Polymer optical fibers (POFs) have several advantages compared to silica fibers. Flexibility and non-brittle nature makes them a potential platform for in-vivo biosensing applications. Their high failure strain and low Young's modulus, makes them suitable for high strain (above 1%) sensing applications and more sensitive to displacement forces. The first FBG written in a single-mode microstructured POF (mPOF), was a 1570 nm grating reported in 2005. Traditionally, POF and mPOFs have been made of PMMA, which makes the response of the FBGs dependent on both temperature and humidity. In 2011, a 1569 nm FBG was written into a TOPAS mPOF, using 325 nm UV writing [2]. Soon thereafter an 871 nm FBG in a TOPAS mPOF was reported and it was demonstrated that the TOPAS FBG was indeed humidity insensitive to within the accuracy of the climate chamber that was used [3]. In all published papers on TOPAS mPOFs, the fibers were made of the particular TOPAS grade 8007, which has a glass transition temperature of only $T_g = 80^oC$. This is even lower than that of PMMA (typically 110^oC), which means that the issue of a low operating temperature remains a problem for polymer FBGs. Here we demonstrate for the first time the fabrication of an mPOF made of high-T_g TOPAS grade 5013 with $T_g = 135^oC$. We further inscribe FBGs into the fiber and demonstrate strain sensing of 2.5% strain at 98^oC, further we also demonstrate strain sensing at a record high temperature of 110^oC[4]. Taking into consideration that the TOPAS fiber is humidity insensitive and that the TOPAS FBG strain sensor may be temperature compensated using dual-FBG technology, this demonstration of high-temperature operation at 110 ^oC provides a significant step towards a practically applicable polymer FBG sensor platform.It should be emphasized that there is not any report so far demonstrating the operation of PMMA POFs or mPOFs at higher temperature than 92°C. Overall, we believe that the current work is a significant step towards fabrication and commercialization of polymer FBG sensors based on TOPAS, which further enhances the ability of polymer fibers to operate at temperatures up to 110°C.



References

[1] Z. Xiong, G. D. Peng, B. Wu, P. L. Chu, "Highly tunable Bragg gratings in single-mode polymer optical fibers," IEEE Photon. Technol. Lett. **11**, 352-354 (1999).

[2] I. P. Johnson, W. Yuan, A. Stefani, K. Nielsen, H. K. Rasmussen, L. Khan, D. J. Webb, K. Kalli, O. Bang, "Optical fibre Bragg grating recorded in TOPAS cyclic olefin copolymer", Electron. Lett., 47, 271–272 (2011).

[3] W. Yuan, L. Khan, D. Webb, K. Kalli, H. K. Rasmussen, A. Stefani, O. Bang, "Humidity insensitive TOPAS polymer fiber Bragg grating sensor," Opt. Express, 19, 19731-19739 (2011).

[4] C. Markos, A. Stefani, K. Nielsen, H. K. Rasmussen, W. Yuan, O. Bang, "High-Tg TOPAS microstructured polymer optical fiber for fiber Bragg grating strain sensing at 110 degrees", Optics Express, Vol. 21, Issue 4, pp. 4758-4765 (2013)